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(54) IMPROVEMENTS IN AND RELATING TO DENTAL IMPLANTS

(71) We, FRIEDRICHSFELD G.m.b.H. STEINZEUG-UND KUNSTSTOFFWERKE, a German Corporate Body of Postfach 7, Steinzeugstrasse 50, 6800 Mannheim 71, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a dental implant for insertion in the jawbone with a biocompatible surface and for securing a superstructure.

The term "biocompatible" is used here as a generic term for "bioinert" and "bioactive". A "bioinert" material is a material which does not exert any influence on the tissue, and in particular does not surrender any ions to the surrounding tissue. A material is designated as "bioactive" which has a favourable influence on the tissue reactions in its vicinity, and, in particular, in the present connection, encourages the formation of bony tissue.

A bioinert dental implant, specifically of aluminium oxide ceramic, is known from Samuel Sandhaus "Neue Aspekte der Implantologie", Medica-Verlag; attention is drawn to pages 156 to 163 in particular. This known dental implant is screwed into the jawbone, all its parts being appropriately shaped for screwing in. The distal end is hexagonal so that screwing in can be effected using a screw spanner. The faces of the implant extending generally perpendicular to the axis of the shank form a thread, the faces of which are orientated towards the distal end. The proximal end is tapered in order to displace the bone during screwing in, and is provided with a gap into which bony material is intended to grow and prevent subsequent twisting.

This known dental implant takes into consideration the requirements of screwing in but not those requirements which must be met in order that the bone formation and bone preservation may be encouraged in the optimum manner in the region of the implant.

According to one aspect of the invention there is provided a dental implant for insertion in the jawbone for securing a superstructure thereto, the implant having a biocompatible surface and comprising a distal end portion provided with a screw socket for anchoring a superstructure thereto, and a shank for insertion in a socket in the jawbone, wherein the thickness of the shank decreases in steps towards the proximal end, the faces connecting the steps extending parallel to the axis of the shank, and the step faces extending perpendicular to the axis of the shank and being orientated towards the proximal end.

According to another aspect of the invention there is provided a dental implant for insertion in the jawbone for securing a superstructure thereto, the implant having a biocompatible surface and comprising a distal end portion carrying an extension which can be ground to a point for anchoring a superstructure thereto, and a shank for insertion in a socket in the jawbone, wherein the thickness of the shank decreases in steps towards the proximal end, the faces connecting the steps extending parallel to the axis of the shank, and the step faces extending precisely perpendicular to the axis of the shank and being oriented towards the proximal end.

In order to preserve the bone as far as possible and to stimulate the jaw to bone formation in the region of the implant, the masticatory pressure must be transmitted to the bone in the same direction as is the case with natural teeth. Natural teeth are orientated substantially perpendicular to the jawbone. Since the jawbone is slightly curved in the tooth-carrying region, the teeth in the rear portion of the jaw are not aligned in the same direction as in the front portion of the jaw. The dental implants should therefore be orientated in the same manner. With the known dental implant, this is not possible because the superstructure is fitted to the hexagonal portion which means that all superstructures will be orientated pre-

cisely parallel. In an implant according to the invention, anchoring of the superstructure is obtained either by providing bores in the superstructure in such a manner that, through such bores, a screw connection to the dental implant is possible at any desired angle or by grinding the extension of the implant to a point suitable in shape and direction.

As an important prerequisite for solving the problem, care is first taken to ensure freedom of choice in the orientation of the implant in the jawbone by the screw socket, the extension which can be ground to a point or another equivalent means at the distal end of the dental implant. As a result of the construction of the steps and the orientation of the step faces towards the proximal end, in an implant according to the invention, the effect is achieved that these faces transmit the masticatory pressure to the tissue present beneath them and stimulate bone formation. In contrast, in the known dental implant, the screw faces on the surface substantially perpendicular to the axis had to be orientated towards the distal end in order to drive the dental implant into the bone. In order to prevent twisting of the known dental implant, a gap is provided at the proximal end into which bone material grows. This inward growth, however, prevents the development of collagenic fibres orientated tangentially to the surface which—regarded three-dimensionally—form a hammock-like structure and support the dental implant resiliently. In an embodiment of implant according to the invention the proximal end of the shank does not comprise any gap but is rounded and has a smooth, uninterrupted surface, and furthermore, in order to secure the implant against rotation, the faces of the shank connecting the steps comprise lacunae which extend perpendicular to the axis of the shank and into which bony tissue grows and prevents twisting of the ingrown implant. The rounded, smooth construction of the proximal end encourages the development of the collagenic fibres which are suspended on a bead of bone, the formation of which is stimulated by the step face adjacent to the proximal end.

With known dental implants, the anchoring in the jawbone was not complete because an interposition of soft tissue always occurred between the implant and the bony tissue. Such a soft tissue has a higher metabolism rate than supporting bony structures. With a given rate of penetration of bacteria, therefore, inflammatory reactions do not so readily occur with conventional implants. With an implant according to the invention there is the possibility of a largely direct bone contact without the interposition of soft tissue, particularly at the faces transmitting the pressure. This means a lower metabolism rate and therefore the implant requires better protection against the penetration of bacteria, which would endanger the growing in and the permanent anchoring of the implant in the bone. Thus, in order to achieve a reliable sealing off from the oral cavity and to facilitate and improve the growth of the epithelium on the implant, the head of the shank may advantageously be provided with a surrounding constriction and be highly polished in the region of the constriction and in the region round the constriction. The epithelium is drawn into the surrounding constriction by means of a tobacco-pouch seam and the gum grows well against the highly polished faces.

In order to improve the security against rotation afforded by the lacunae, the cross-section of the shank may advantageously be made non-circular. For this purpose, for example, the cross-section of the shank may comprise at least one straight boundary line or the cross-section may be elliptical, in which case the ratio of the two axes of the ellipse to one another may advantageously be 1 to 3. The elliptical construction is particularly to be recommended if the implant is to be placed in the region of the molar teeth.

The shape and depth of the lacunae may be different on the different faces of the shank. In an advantageous embodiment the plan view of the lacunae (seen in the direction perpendicular to the axis of the shank) is round, the diameter (d) of each lacuna being between 0.15 and 1 mm and the depth (t) of the lacuna being about half the diameter. Alternatively, the plan view of the lacunae (seen in the direction perpendicular to the axis of the shank) may be square, the side (d) of the square being between 0.15 and 1 mm long and the depth (t) of the lacuna being about half the side length. Finally, the plan view of the lacunae (seen in the direction perpendicular to the axis of the shank) may be elongated, the width (d) of the lacuna measuring between 0.15 and 1 mm and the depth (t) of the lacuna being about half the width.

If an implant is needed for insertion in two or three sockets which have become free as a result of extraction, then one head, which comprises the surrounding constriction indicated, may advantageously carry two or three shanks as described above, the shanks carrying a common head for the passage through the epithelium.

In order to increase the mechanical strength, the dental implant preferably consists of a metallic core with a covering of biocompatible material. In this case, the metallic core may advantageously consist of high-strength steel. As a high-strength steel, all steels having a high tensile strength

may be considered which retain or substantially retain this high strength at body temperature even after a large number of load reversals. The precise dimensioning must be based on the strength remaining after a large number of load reversals. In addition, this steel must pass through the heat treatment necessary for the application of the biocompatible covering, if possible without any loss of strength, or the strength values which apply after this heat treatment must be used for the dimensioning. If the biocompatible covering is applied by one of the well-known flame-spraying processes or by another method which only influences the surface of the steel, then there is the least alteration in the strength of the core of high-strength steel.

The biocompatible surface (that is to say the covering in the case where a metallic core is used) may advantageously consist of a ceramic which is free of open pores, i.e. pores which are open to the outside or to adjacent pores ("through-going porosity"). Such a "soundness" is a prerequisite for adequate strength, complete protection of the metallic core from corrosion by body fluids and an ability to be polished satisfactorily.

A satisfactory biocompatibility of the aluminium oxide ceramic is assured if it contains at least 95% by weight, preferably at least 99% by weight of aluminium oxide. Impurities can disturb the biocompatibility. For example, titanium is often designated as biocompatible in the literature but it has been found that ions pass from this metal into the tissue and there cause discolouration of the tissue for example. Aluminium oxide ceramic with a high aluminium-oxide content also has more strength than severely contaminated aluminium oxide ceramic.

The biocompatible surfaces are preferably not only bioinert but in addition bioactive, that is to say they contain special ions, preferably in the form of a glass ceramic. These ions control the bone reactions and stimulate the growth of the bone on the prosthesis. The bone formation is improved, in that a transition region is formed between the living bone and the dead prosthesis. Thus as areal connection is obtained between the dental implant and the bony tissue through biochemical reactions, for example as a result of the fact that surface constituents from the dental implant initiate the bone formation in the adjacent tissue and cause the development of a transition layer between the implant and the bony area.

Lithium, boron, carbon, fluorine, sodium, magnesium, silicon, phosphorus, potassium and/or calcium ions have proved particularly satisfactory for controlling the tissue reactions.

It is an advantage if only the faces perpendicular to the axis of the dental implant, that is to say the step faces and the faces of the proximal end, are bioactive in the manner described. In this way, the effect is achieved that the faces connecting the steps do not grow together with the surrounding bony tissue or do so to a lesser extent, as a result of which a slight mobility of the implanted dental implant in relation to the surrounding tissue is possible in the axial direction. In such a case, therefore, the faces connecting the steps are bioinert.

If the dental implant according to the invention is given a metallic core, for example of high-strength steel, then the biocompatable surfaces or bioactive surfaces should be applied to the core as coverings. These coverings should adhere firmly to the core. For this purpose, at least one intermediate layer may advantageously be provided between the covering and the core, for example an intermediate layer applied galvanically. Methods of applying such layers are generally known.

An embodiment of an implant according to the invention has been found to grow well into the jaw and can be loaded after about four months. An optimum growth of the epithelium is achieved as a result of the construction of the head with surrounding groove and highly polished surfaces.

The invention will be more fully understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 shows an embodiment of a dental implant in accordance with the invention in elevation;

Figures 2 and 3 show the head, as seen in the direction of the arrows II and III respectively in Figure 1;

Figures 4, 6 and 8 are the plan views of alternative lacunae which may be formed in the implant of Figure 1;

Figures 5, 7 and 9 show sections of the lacunae shown in Figures 4, 6 and 8 respectively; and

Figures 10 and 11 show dental drills which can be used in implanting the implant of Figure 1.

The dental implant illustrated in Figure 1 comprises, at the distal end, a head 10 which is connected with a shank 12 of decreasing section towards the proximal end 18.

A screw socket 14 made of gold and/or platinum is cemented into the head 10 as an anchoring for a superstructure.

Substantially centrally, the head 10 comprises a surrounding groove 16. In this groove and in the region round this groove, the outer surface of the head is highly polished in order to facilitate growth of the epithelium.

The shank 12 is of one-piece construction. Formed at the transition from the head 10 to the shank 12 is a first step, the annular step face 1 of which extends perpendicular to the axis 7 of the shank. The diameter d_1 of the uppermost section of shank is smaller than the diameter of the head 10. Following on this uppermost shank section, with a reduction in cross-section and forming another annular step face 2, is the second shank section with a smaller diameter d_2. The shank continues in further sections with the diameters d_3, d_4 and d_5, forming further step faces 3, 4 and 5. The proximal end 18 of the shank is rounded off, is completely smooth and does not comprise any grooves or other precautions against rotation so that the formation of collagenic fibres is not disturbed there.

The shank 12 and its head 10 consist of pore-free, highly pure aluminium oxide ceramic, that is to say this ceramic contains at least 96% by weight and preferably at least 99% by weight of aluminium oxide. The tissue of the bone or of the epithelium grows particularly well on this very pure material.

As can be seen in Figure 2 and particularly Figure 3, the cross-section of the head is round; the cross-section of the shank 12, on the other hand, is preferably non-circular, as described above, in order to avoid twisting of the implant. In certain circumstances, however, lacunae provided in the faces f_1, f_2, f_3, f_4 and f_5 connecting the steps to one another are sufficient and their plan (seen perpendicular to the axis 7 of the shank 12) may, for example, be round (Figure 4), square (Figure 6) or elongated (Figure 8). Figures 5, 7 and 9 represent the sections of the lacunae shown in Figures 4, 6 and 8 respectively. The depth (t) of each lacuna is equal to half the diameter d (Figure 4) or equal to half the width d (Figures 6 and 8) of the lacunae. The length l of the lacuna shown in Figures 8 and 9 is preferably orientated perpendicular to the direction of the axis 7, in order to provide the largest possible areas loading the bone in the direction of the masticatory pressure and so to stimulate the tissue to bone formation.

The implantation of a dental implant as described above is effected immediately after the extraction in the freshly opened socket or in an artificial socket. The implantation is particularly simple if the cross-section of the shank 12 is round. In this case, the freshly opened socket is preferably preliminarily drilled with a tapered drill as shown in Figure 10, the direction of drilling not necessarily having to coincide with the direction of the socket. The hole is then finally drilled out with the drill illustrated in Figure 11 with an accuracy of fit of 0.1 mm. Drilling is preferably effected by hand because in this case the implant holds better and no burning of the tissue occurs as when a high-speed automatic drill is used.

For implants with non-circular shanks 12 suitable vibrating milling cutters are used instead of the drills illustrated in Figures 10 and 11.

WHAT WE CLAIM IS:—

1. A dental implant for insertion in the jawbone for securing a superstructure thereto, the implant having a biocompatible surface and comprising a distal end portion provided with a screw socket for anchoring a superstructure thereto, and a shank for insertion in a socket in the jawbone, wherein the thickness of the shank decreases in steps towards the proximal end, the faces connecting the steps extending parallel to the axis of the shank, and the step faces extending perpendicular to the axis of the shank and being orientated towards the proximal end.

2. A dental implant for insertion in the jawbone for securing a superstructure thereto, the implant having a biocompatible surface and comprising a distal end portion carrying an extension which can be ground to a point for anchoring a superstructure thereto, and a shank for insertion in a socket in the jawbone, wherein the thickness of the shank decreases in steps towards the proximal end, the faces connecting the steps extending parallel to the axis of the shank, and the step faces extending precisely perpendicular to the axis of the shank and being orientated towards the proximal end.

3. A dental implant as claimed in either claim 1 or claim 2, wherein the distal end portion has a peripheral constriction and is highly polished in the constriction and in the region round the constriction.

4. A dental implant as claimed in any one of the preceding claims wherein the shank has a non-circular cross-section.

5. A dental implant as claimed in claim 4, wherein the cross-section of the shank comprises at least one straight boundary line.

6. A dental implant as claimed in claim 4, particularly for use in the region of molar teeth, wherein the cross-section of the shank is elliptical.

7. A dental implant as claimed in claim 6, wherein the ratio of the two axes of the ellipse is 1 to 3.

8. A dental implant as claimed in any of the preceding claims wherein the faces connecting the steps comprise lacunae and the proximal end of the shank is rounded and has a smooth uninterrupted surface.

9. A dental implant as claimed in claim 8, wherein the plan of each lacuna (seen in the direction perpendicular to the axis of the shank) is round, the diameter of each

lacuna being between 0.15 and 1 mm and the depth of the lacuna being about half the diameter.

10. A dental implant as claimed in claim 8, wherein the plan of each lacuna (seen in the direction perpendicular to the axis of the shank) is square, the length of the side of the square being between 0.15 and 1 mm and the depth of the lacuna being about half the length of a side.

11. A dental implant as claimed in claim 8, wherein the plan of each lacuna (seen in the direction perpendicular to the axis of the shank) is elongated, the width of the lacuna being between 0.15 and 1 mm and the depth of the lacuna being about half the width.

12. A dental implant as claimed in any one of the preceding claims, comprising at least a second shank similar to the first mentioned shank.

13. A dental implant as claimed in any one of the preceding claims made of a metallic core with a covering of biocompatible material.

14. A dental implant as claimed in claim 13, including at least one intermediate layer between the covering and the core.

15. A dental implant as claimed in either claim 13 or claim 14, wherein the metallic core consists of high-strength steel.

16. A dental implant as claimed in any one of the preceding claims, wherein the biocompatible surface is made of Al_2O_3 ceramic which is free of open pores.

17. A dental implant as claimed in claim 16, wherein the Al_2O_3 ceramic contains at least 95% by weight, preferably at least 99% by weight, of Al_2O_3.

18. A dental implant as claimed in any one of the claims 1 to 15, wherein the step faces and the proximal end of the shank only are bioactive, these surfaces containing ions to control the tissue reactions and to stimulate the growth of tissue.

19. A dental implant as claimed in claim 18, wherein the bioactive surfaces one made of a glass ceramic.

20. A dental implant as claimed in either claim 18 or claim 19, wherein the ions for controlling tissue reactions are lithium, boron, carbon, fluorine, sodium, magnesium, silicon, phosphorus, potassium and/or calcium ions.

21. A dental implant substantially as herein described with reference to the accompanying drawings.

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1544784 COMPLETE SPECIFICATION

2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

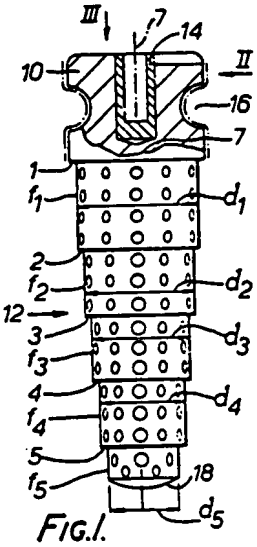

FIG.1.

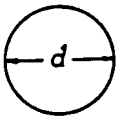

FIG.4.

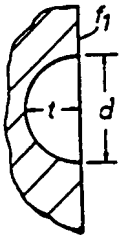

FIG.5.

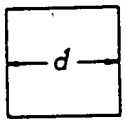

FIG.6.

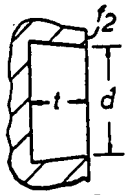

FIG.7.

FIG 2

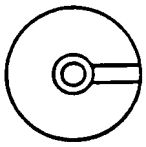

FIG.3.

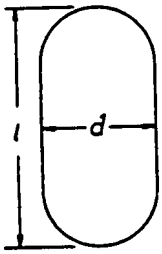

FIG.8.

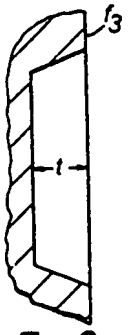

FIG.9.

1544784 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

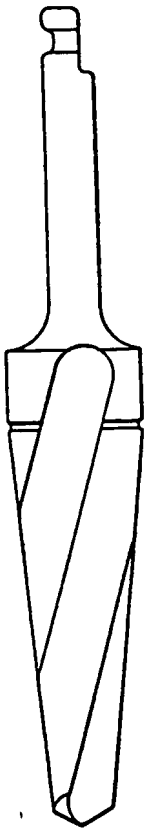

FIG. 10.

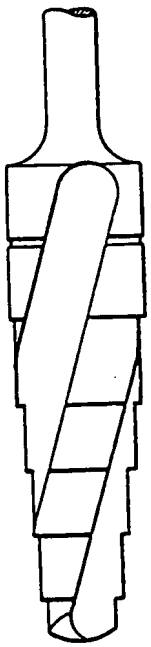

FIG. 11.